Pollution Changes Clouds' Ice Crystal Genesis

Research Highlight

Suspended high in the atmosphere, plentiful dust particles are fertile turf for growing ice. But, what are the optimal conditions for this crop? Researchers at Pacific Northwest National Laboratory (PNNL) found that miniscule particles of airborne dust, thought to be a perfect landing site for water vapor, are altered by the pollution they encounter in the atmosphere during their cross-continental journey.

By modifying dust particles in the laboratory to mimic this process, the team was able to measure their cloud-ice-forming potential, discovering some conditions are more favorable than others. And when modeling their behavior, they found that these pollution-modified particles have a large influence on cloud properties via ice crystal number concentration and ice water content.

In a previous study, a PNNL-led team focused on dust particles altered by sulfuric acid found in pollution from sulfur dioxide emissions that come primarily from coal-fired power plants. Led by PNNL, the cross-functional research team, working under a measurements-to-modeling paradigm, investigated the ice nucleating properties for different dust samples affected by another kind of pollution. In the new study, they looked at particles that were fresh and those that were aged by a coating of nitric acid, which results from several nitrous oxide emissions that are primarily from vehicle exhaust and biomass burning. Using this information, they implemented formulas (parameterizations) describing the information gained from the laboratory ice nucleation measurements and implemented this into the global model. The revised model was adjusted based on the U.S. Department of Energy's Atmospheric Radiation Measurement Climate Research Facility's Southern Great Plains (SGP) site observations. Researchers then ran the revised model to understand the influence of the pollution-like coating on particles within ice containing clouds.

They found that all the dust particles nucleated ice well in subsaturated conditions, though the acid-coated particles showed slightly less efficiency in nucleation than the bare particles. At supersaturated atmospheric conditions, bare and coated particles had a nearly equivalent predisposition for nucleating ice.

More than half the Earth's precipitation comes from ice-bearing clouds formed via several ice-forming mechanisms. Clouds and how they are formed are a difficult simulation challenge for climate models. Scientists are working to understand their underlying processes, such as which particle surface properties encourage or discourage ice formation, called nucleation, so they can accurately simulate how, where, and when clouds are formed. Understanding how dust particles are affected by each type of pollution will shed light for researchers to account for all types of pollution when computing which particles may form ice crystals in cold clouds. This study advances understanding of the ice nucleation processes, especially under the presence of pollution emissions, which ultimately will contribute to knowledge about global changes in precipitation.

Pollution, caused by sources such as biomass burning in the tropics, comes in contact with dust particles in the atmosphere, and the particles are changed in a way that affects their ability to form ice crystals in cold clouds. Since more than half the world's precipitation comes from cloud ice, it's important to understand all the ways those ice particles may be increased or decreased. Image courtesy of NASA

Reference(s)

Kulkarni GR, K Zhang, C Zhao, M Nandasiri, V Shutthanandan, X Liu, L Berg, and J Fast. 2015. "Ice formation on nitric acid-coated dust particles: Laboratory and modeling studies." Journal of Geophysical Research – Atmospheres, 120(15), doi:10.1002/2014JD022637.

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Cloud Life Cycle